Technological Mediation of Ontologies: the Need for Tools to Help Designers in Materializing Ethics

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Abstract

Philosophers of technology such as Peter-Paul Verbeek have addressed the issue of the effects that concrete technologies have on the experience and existence of humans that use them. Drawing on his studies, in this article, the theory of technological mediation was applied to a particular type of technology: the ontologies used within the Semantic Web. Differing from other artefacts, the mediation effects of ontologies is realised indirectly through the applications that embody them as abstract schemas or meta-models. This phenomenon, called meta-mediation, was analysed from the point of view of all the stakeholders involved in the development and use of an ontology. A case study was used to exemplify how ontology differences may affect the way people perceive a web service. This analysis showed that ontology engineering is an inherently moral activity which needs adeguate tools and methodologies to support a more mediation aware approach to design of products and services. Some proposal aimed at this goal have been discussed as well.

Keywords

Technological Mediation; Ontologies; Web Services; Ethics; Semiotics

Introduction

Recently, researchers in the fields of Philosophy of Technology and Science and Technology Studies focused their work on the role of technological *mediation* and ethical aspects linked to this process [Verbeek, 2006].

Technologies can influence agents and agency in several ways. They can be instruments, enabling and facilitating actions, changing what we *can do* while leaving the choice up to us; however, they can also change what we *actually do* suggesting people to do certain actions instead of others or changing the way people feel reality toward the use of these technologies.

Unfortunately, there is a lack of specific studies about mediation processes related to new information technologies and to the Web [Pieters, 2013]; current studies prefer to focus on technical dispositive: speed bumps, doors with spring mechanisms, photovoltaic kits, etc. [Latour, 1992; Akrich, 1992]. In this paper, the focus will be placed on a particular Semantic-Web technology: ontologies.

Ontologies are a particular embodiment of knowledge, methods, and even philosophy. When seen as meta-models, they can be pushed into artefacts and embedded in working environments, shaping them and guiding in this way user's experience and expectations. The *guiding* concept is strictly related to the concept of *meaning (i.e. sense as privileged trajectory)* [Akrich and Latour, 1992]: an ontology gives meaning to the artefact in which it is embedded.

The goal is to explore the way ontologies realize technological mediation processes toward the artefacts that contain them.

Instead of the traditional focus on quantitative technological risk, we studied technology's soft impacts: how technology influences values, norms, aspirations, needs, identities, responsibilities, meanings, and power relations. This subject introduced different ethical aspects related to the effects (on user experience and user behaviour) of adopting ontologies.

Following, some interesting questions have been listed emerging from this subject. At present, we are not able to answer all these questions in a homogeneous way but it is an interesting starting point for a deeper analysis.

- How can we use technological mediation towards ontologies?
- Which aspects of ontologies are involved (and *how* they are involved) in this process?

- How can we make ontology engineers and users be aware of the effects of this mediation?
- Do there useful tools support the analysis of ontology-generated mediation processes and the evaluation of in-use effects?
- Are there useful tools supporting ontology designers in projecting ontologies using ethically sustainable practices?

For this purpose, some ontologies proposed in literature will be compared to model web services with the purpose to analyse some differences between these ontologies and to link these differences to predictable effects on user experience.

This paper has been organised in the following way. In the first section, the concept of ontology viewed as a meta-model and discuss differences among ontologies at the knowledge level as well as rationales for variance was introduced. The second section was devoted to brief review of the concept of technological mediation as it has been proposed in the field of post phenomenology by Verbeek. In the same section, the framework was applied to service ontologies. In the third section consequences on design have been briefly discussed. Finally, the last section drew conclusions.

Ontologies

The Semantic Web (SW) term was defined as [Berners-Lee et al., 2001]. The purpose of Semantic Web is to overcome some limitations of Web 2.0 by augmenting web information with a formal (i.e. machine readable) representation of its meaning, i.e. ontologies.

Informally, an *ontology O* is a triple <*C, AX, CQ*> where:

- C is a conceptualization that specifies conceptual primitives–i.e. the types of entities, relations, attributes (of entities and relations) with associated domains of possible values-describing the domain of interest and the dictionary;
- AX is a set of axioms specifying constraints that must be satisfied by the elements of the conceptualization;
- CQ is a set of competency questions specifying questions/issues that an ontology can ask (i.e. different queries) on the base of its conceptualization.

In this study, a modelling approach was adopted and an ontology was viewed as a meta-model [Toppano et al., 2008]. A *meta-model* is an explicit description of the constructs and rules available to build specific models within a domain of interest.

A specific model is created by instantiating the conceptual primitives and relating instances to each other according to the relationships and axioms in the meta-model. This way the ontology *informs* the specific models built on the base of its conceptualization, projecting into them the structure and the meaning of the conceptualization itself.

It is important to stress that an ontology as meta-model has the whole set of characteristics of models: incompleteness, approximation, point of view, etc. So there is not an unique ontology but there are *several* ontologies representing a domain from different points of view and using different terms and formalization. For the purpose of this paper, the attention was focused on possible occurring differences between ontologies, particularly, the differences between conceptualizations (the knowledge level) more than the differences related to the different languages used to formalize them (the symbolic level).

Visser's et al. work [1997] is useful in this context because it gives us a framework to analyse and compare conceptualizations. Visser proposed an ontology mismatches classification based on the distinction between *domain conceptualization activity* (concept identification) and *explication of conceptualization* (concept definition and denotation).

The main idea is that mismatches may occur in both processes. Conceptualization mismatches arise whenever differences occur in the types of concepts that are identified in a domain of interest or in the way in which those concepts are related. Explication mismatches occur when two conceptualizations have different definitions but their terms or their concepts are the same. For further information reads Viesser et al. [1997].

The purpose of analysing the differences between ontologies is to harmonize them (i.e. to integrate, merge or make them interoperable).

Aside from some very general studies [Lakoff, 1987] there is a lack of specific analysis on what kind of consequences or effects do have some ontology's differences on the experience and behaviour of potential users. An important contribution for the purpose of this paper is about the study of the origin of ontology mismatches of [Smart et al., 2008], where different factors have been identified that contribute to ontology mismatches.

Unfortunately, Smart's study lacks an analysis on how culture may influence the process of designing ontologies and how it could be reflected in the final artefact. A starting point for this kind of study can be found in [Anticoli at al, 2011]. There is also no analysis of socio/ideological causes that may affect the conceptual content and the ontology structure: e.g. using points of view expressing specific values and interests to share them among different professional communities.

Technological Mediation

There are studies analysing the concept of mediation from many points of view. [Bodker at al., 2005] analysed the concept of mediation from the point of view of Action Theory and Semiotics respectively with the purpose to link aspects of human activity (action) with their interpretive processes (semiosis). [Chandler, 1995] analysed mediation processes of language and new media whilst [Verbeek, 2006a] investigated the concept of mediation in the field of Philosophy of Technology and [Latour and Akrich, 1992] in the field of Action Network Theory.

Later on, the concept of Technological Mediation was referred to as conceptualized in [Verbeek, 2006a]. According to Verbeek (the use of) a particular technology affects the relation between user and world in two ways: by a process of transformation of experience and perception of the world (*mediation of perception*) and by transforming user's praxis or action in the world (*mediation of action*). The effect of mediation of perception is realised by an amplification or reduction of the experienced aspects of reality while the effect of mediation of action is realised towards an invitation or inhibition to perform certain actions instead of others.

How can we specialize the concept of mediation in the ontological context? An ontology realises a mediation of perception process toward its conceptualisation and axioms. Its conceptualisation brings some aspects of the world into sharp focus at the expense of blurring other aspects Not only the concepts but also the way they are internally structured are significant. Hierarchical structures (i.e. typologies, mereologies) tend to focus the attention on particular relations between concepts (i.e. typeOf, partOf) and to support analytic processes of generalisation/specialisation or decomposition/aggregation. Eterarchical structures tend to focus the attention on associative relations (i.e. sameAs, equivalentTo) promoting, for example, representations of a unique domain by different points of view. In [Anticoli at al., 2011] there is the hypothesis that different structures may be the result of a different cultural heritage of designers: more analytic-oriented for hierarchical structures, more holistic-oriented for eterarchical structures.

The mediation of action is strictly linked to the ontology's competency questions. *Competency questions* specify the functional aspect of an ontology: for which goals do we use it? When?

An ontology has an indirect mediation role: it establishes the conceptual background, which allows the end user to interpret and use the technology. It is important to remember that in this context three types of stakeholder (Figure 1) is taken into consideration:

i) ontological engineer;

ii) designer of a web application;

iii) users.

It is important to note that with this three terms (ontological engineer, designer and user) attention is paid to some functional roles that might be interpreted by a single person or by groups/teams. Designer means everyone involved in the process of designing an application, like analysts and proper designers. Moreover, part of this design process also clients, sponsors etc are considered.

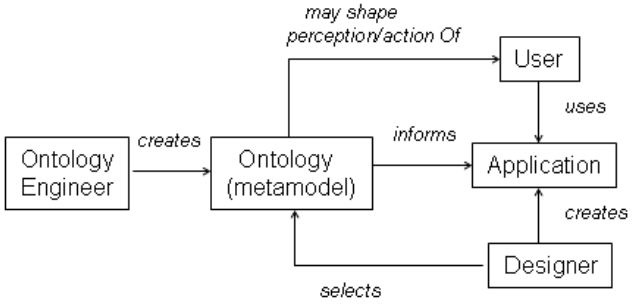

FIG. 1 GENERAL FRAMEWORK FOR STUDYING ONTOLOGICAL MEDIATION

Ontological engineer creates an ontology that can be selected by the designer and pushed into the application as a meta-model and emerges when used by the end user. Therefore, the technology that contains the ontology mediation indirectly operates it. We shall call this process *meta-mediation* to distinguish it from the *ordinary mediation* process operated by the artefact with which the user interacts.

The ontology influence acts in the background: it establishes the conceptual background, which allows the end user to interpret and use the technology. A specific ontology is often incorporated in development

systems for applications or web products so it's automatically adopted by developers that use this systems to develop their application.

We can analyse in detail the concept of meta mediation using some concepts from the Action Theory and from Semiotics [Bodker et al, 2005].

The paradigm case (Figure 2 left) of Action Theory is a material situation in which a Subject uses a Mediator (Tool) to achieve an Object-Goal (e.g. to change the state of the object or to access its state). As an instance, the carpenter (Subject) hit the nail (Object) with the hammer (Mediator-Instrument).

On the other hand, Semiotic is the discipline that focuses on construction and communication of the meaning. Andersen, referring to the triadic model of sign proposed by Peirce, gives the concept of Interpretation to the role of mediator between object and representation [Bodker et al., 2005]. This is described in Fig. 2 at the right side, in which a representation R denotes an object O under a given interpretation I

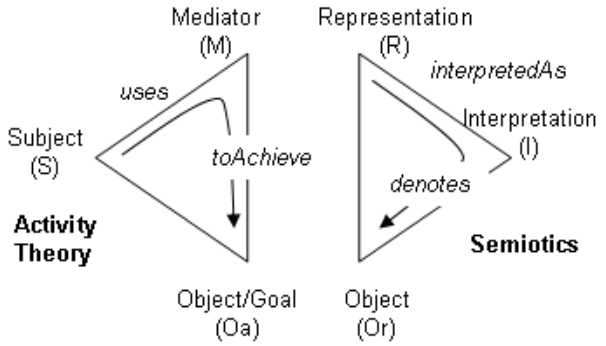

FIG. 2 ACTION THEORY AND SEMIOTICS TRIANGLES

These two triangles (Action Theory triangle and Semiotics triangle) are combined to describe the previously discussed process of meta-mediation as follows:

- In the activity of constructing ontologies: the ontological engineer (Subject) uses a tool for developing ontologies (Mediator) to build up the service/ product ontology (Object-a). In turn, this resulting ontology (Representation) denotes the conceptualisation of the product/ service (Object-r) from the ontological engineer's point of view (Interpretation).
- In the activity of developing a web application: the designer of product/service (Subject) uses the ontology as meta-model (Mediator) of the application he wants to develop (Object-a). In addition, the application (Representation) denotes the product/service ontology (Object-r) embedded from the point of view of the ontological engineer (Interpretation).
- In the activity of using the application: the user (Subject) uses the product/service (Mediator) in order to realise his/her purposes/needs (Object-a). As it has already been seen before, the application (Representation) denotes the embedded product/service ontology (Object-r) from the point of view of the ontological engineer (Interpretation). This permits the user to access (more or less consciously) the conceptual model that informs the application he/she is using, possibly understanding and interiorising it.

In order to discuss the previous points, some observations can be made:

- In meta-mediation, the object of an activity becomes mediator in the following activity. So, the ontology–object in the ontological engineering activity–becomes mediator in the activity of developing a web application. The latter itself becomes mediator in the user's activity. These two steps realize the background mediation role of the ontology;
- The building of an ontology of a given domain requires the selection of concepts and relations which are deemed as important according to intended purpose, objectives and scale of values. Consequently, some concepts are explicitly represented or can be inferred by the explicit ones; while other concepts are completely ignored. Selecting certain aspects of the domain reflects their importance in the eye of the user, so some "realities" are more accessible (or better, "more real") than others. Selectivity can empower the opinions of certain lobbies and this influences the distribution of values and power in our society;
- The adoption of an ontology from a designer-developer implies a commitment to its conceptualization, and indirectly to its values.
- The application may co-shape the perceptual experience of the user. Here, we use "may" because we do not want to fall into technological determinism. The effect of a technology is a complex process, which comprehends many factors: the intentions of the developers, the characteristics of the final application, the use of the application as

thought by the engineer and the actual use by the end user. These elements, with their complex interaction, create the effect of multistability introduced by Ihde [Ihde, 1990], making harder to predict how the application will influence the user behaviour;

- The user uses the artefact (and so its ontology) but is also used by the artefact and by the ontology: he/she must adapt his/hers goals and behaviour to the one made available by the conceptualization and competency questions that inform the artefact. The importance of this transformation effect depends on how much the meanings associated to an ontology are personally relevant and useful for the user. This aspect is particularly important because influences engagement and attachment of the user to the application that incorporated the ontology, and so the success of the application itself.

Furthermore, the frequent use of the application by an advanced user that knows how to use it, makes the application become transparent and the mediation function done by the incorporated ontology be unnoticed.

A Case Study: Generic Ontologies of Web Services

A web service (WS) is a software component that allows access to its functionality via a web interface. An analysis of differences from products and services of technological mediation can be found in [Pieters, 2013]. In this paper, the focus was on generic ontology of WSs. A *generic Web Service ontology* provides a general meta-model of what is and how is a WS made independently from the application domain. Several generic ontologies have been proposed for WSs [Cabral et al., 2004] with the focus on two of them: OWL-S and WSMO.

This ontologies have a comparable coverage: they refer to the description of a *computational web service* and focus on functional aspects [Lara et al., 2005; Sorathia et al., 2010]. The remainder of this section summarizes the main characteristics of both ontologies.

OWL-S

The OWL-S ontology is divided into four sub-ontologies:

- S-Profile: specifies what a service does i.e. the functionality offered by the service (e.g. buying a book) the semantic type of inputs and outputs and other details (parameters) that can be used to discover the service;
- S-Model: specifies how the service works; many complex services consist of smaller services executed in a certain order. OWL-S allows describing such internal process models. For example buying a book involves invoking a browsing service (which selects the book) and a paying service. A profile is linked with the processes that realise it.
- S-Grounding: provides a vocabulary to link the conceptual description of the service, specified by the profile and process (model) to actual implementation details, such as message exchange formats and network protocols.
- Service: links together the above sub ontologies. As shown in Figure 3, the Service presents a service Profile, described by a service Model and supports a service Grounding.

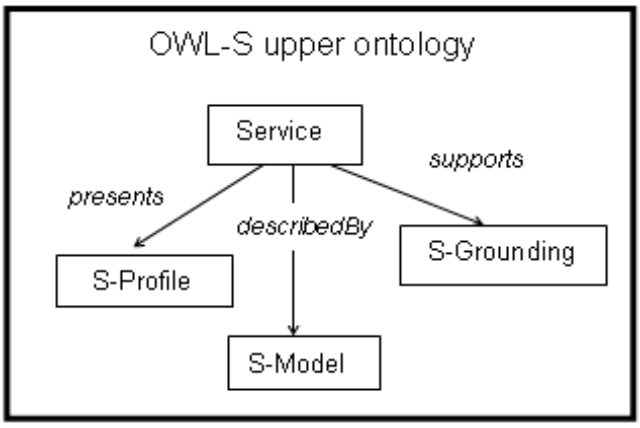

FIG. 3 MAIN ELEMENTS IN THE OWL-S ONTOLOGY

WSMO

WSMO (Web Service Modelling Ontology) relies on four main components inspired by the conceptual work done in the definition of WSMF (Web Service Modelling Framework), namely:

- Ontologies: provide terminology and formal semantics to describe the other elements of WSMO;
- Goals: these elements provide the mean to specify the requestor's side objectives when consulting a WS, describing at a high-level a concrete task to be achieved. A goal specification consists of two elements: preconditions (describe what a web service expects for enabling it to provide its service) and post conditions (describe what a web service returns in response to its input)
- Web Services: provide a semantic description

of WS including the functional and non-functional properties as well as other aspects relevant for interoperating with them, including the concept of capability (defines the functional aspects of the offered service); interface (gives details about the service operation in terms of its choreography and its orchestration). Choreography refers to how the service works and how to access it from the user's perspective. Orchestration refers to how a service makes use of other WS's or goals to achieve its capability. It's important to note that services–and so their models–can be combined to realize complex services, which can be both "hardwired" or generated in real time.

- Mediators: these modelling elements are connectors that resolve heterogeneous problems in order to enable interoperation between heterogeneous parties. They mediate among ontologies and formats, structures of messages and business logics.

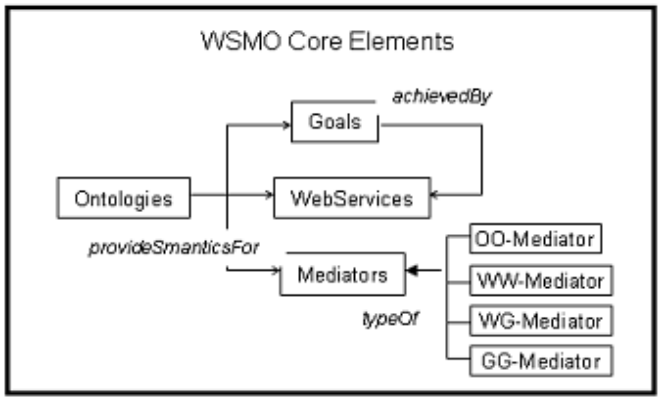

FIG. 4 MAIN ELEMENTS IN THE WSMO ONTOLOGY

Comparison

By comparing the two described ontologies, some conceptual differences emerge:

- In WSMO, there are two different concepts– the goal and the WS capability–to represent the objectives that a client may have when consulting a web service (service requester's point of view) and the functional aspects of the offered service (provider's point of view).
- In WSMO, choreography and orchestration can be distinguished.
- These distinctions do not appear in OWL-S that uses a single concept (the service) to represent both the client's point of view and the provider's point of view and there is no concept similar to orchestration. Moreover:
- WSMO introduces the important concept of the Mediator, to handle problems of semantic heterogeneity (e.g. caused by differences in conceptualization) that inevitably shows in open and distributed environments. For example, semantic differences between expression of the goal and the capabilities may be taken into consideration.
- OWL-S does not explicitly consider the problem of semantic heterogeneity: mediators are not an element of the ontology but are part of the underlying WS infrastructure.
- While WSMO associates different interfaces to the same service, OWL doesn't.

WSMO recognizes that different perspectives exist and that it is important to keep and organize them, while OWL-S doesn't; so, WSMO gives a value to the *difference* between several points of view. OWL-S presumes the existence of a single shared point of view and this surfaces the problem of semantic heterogeneity.

This is corroborated by the possibility offered by WSMO of constructing different interfaces for the same service, i.e. different user experiences for different cultures. It's well known that this different orientation is typical of two very different cultural models: the analytical western culture and the holistic eastern one [Anticoli at al., 2011].

Consequences on Design

The analysis of the technological mediation operated by an ontology shows that the ontology engineering is an inherently moral activity. When the ontological engineer designs an ontology, he is implicitly, inevitably (and often, unconsciously) tackling an ethical problem. Ethics is about the moral question of how to act and, as written in [Verbeek, 2006b] technologies appear to give material answer to this question.

Technological mediation, performed by ontologies, can be tackled in two different ways:

- During the development of an ontology, the ontological engineer can try to imagine the different impacts (both in perceptive and pragmatic way) that the ontology may have once incorporated in an application, and evaluate if this impact is ethically sustainable or not (mediation in ontology).

- The ontological engineer may want to build an ontology that is able to perform a specific mediation during use (ontology for mediation).

In both ways, it's important to build a–necessarily empirical–design knowledge that can link choices about ontology components (conceptualization, axioms, competency questions) with the effects that these choices can potentially have in terms of perceptual mediation. For example, it may be interesting to explore in depth the impact of culture on the way conceptualizations are structured [Anticoli et al., 2011]. This kind of studies is particularly important for the activity of internationalisation and localisation of web application (e.g. websites).

It's also fundamental to introduce some evaluation criteria that allow asserting (or negating) the acceptability of the mediation effects. It was thought that a life-ethical approach discussed in [Verbeek, 2006b], albeit harder to apply with respect to more traditional action-ethical approaches, is particularly suitable in our context since it focuses on the quality of experiences introduced by mediating technologies and their implications for the kind of life we are living.

The remaining perspectives were examined, i.e. the problem of which ontology choose as meta-model for the design of an application and the use of this application by the user. It has been observed that in both cases the effect of technological meta-mediation operated by the ontology incorporated in the application is explicated in a way that makes the reuse of an ontology aware of the potential impact and so more responsible. The goal is to allow a conscious choice both by the developer and the user.

The approaches currently used for the annotation of ontologies are not suitable for this goal [Hartmann et al., 2005; Gangemi et al., 2006]. [Gangemi et al., 2006] proposed a rich set of metadata to specify structural aspects of an ontology and functional and pragmatic aspects (purposes, use contexts) ignoring other functions. However, if the ideological and social function is taken into account, the reuse of an ontology is not just a *technical* problem, but also a *socio-political* one. The reuse of an ontology that happens though the technologies that incorporate it, allows the diffusion of a specific point of view, which has the possibility to spread inside a society and allows the creation of community that endorses and supports it. The adoption of particular persuasion techniques [Fogg, 2003; Cialdini, 2001] in the application development–for example, personalisation techniques–makes that spreading process easier.

A preliminary proposal in this direction has been described in [Toppano et al., 2009], where a semiotic perspective is adopted to describe the collaborative development process of an ontology as interplay of two parallel and strictly related activities: an activity of construction of the conceptualization and an activity of clarification and definition of the meaning associated. The basic idea is to explicitly represent through a narrative text the process of collaborative construction of the ontology meaning including all contextual knowledge (e.g. assumptions, points of view, mediation intentions) motivating design choices. This text will accompany the ontology during its life cycle and can be exploited for selection and evaluation. The explication of information referring to the development process requests to modify the way we watch at ontologies: not only as meta-models of a domain of interest but also as representations of the "process itself of representation of the domain of interest". This way the fact is underlined that the ontology is an artefact, i.e. the result of choices.

Conclusions

In this paper we tried to apply the concept of technological mediation in a particular type of technological artefact: ontologies. Differently from traditional physical products which have an impact limited by their physicality and their behaviour, ontologies have a mostly immaterial impact, which refers to the social and cultural effects of the diffusion of the conceptualization they represent.

Technological mediation operated by ontologies depends directly on the conceptual structure, as thought by the ontological engineer, and indirectly by the competency questions which describe the possible uses of conceptualizations. The fact has been stressed that mediation is not direct but happens through the applications in which the ontology is adopted as meta-model. This complex process that we've called meta mediation, has been analysed in detail and conceptualized using some tools offered by Action Theory and Pierce's Semiotics. The analisys of two generic ontologies for web services permits to identify some conceptual differeces that might influence the way users perceive a service, supporting different points of view about the ways an activity may be decomposed into one or more sub-activities.

The latter part of the work focalized on ethics. If ontologies can affect people's behaviour and people's

relationship with the outside world, the design of an ontology is an ethic activity and the ontology itself is a materialization of values and ethical choices. Three moments were observed in which the impact of an ontology can be evident: during its development, during the choice of the ontology and its embedding within a web application and during the use of the application. It was claimed that it's necessary to build tools and methods which are able to support the stakeholders involved in the development and informed use–i.e. mediation aware–of ontologies. Some methodologiacal proposals are in [Verbeek, 2006b]. A technique called "anticipation by imagination" is very simple to use: in which designers are asked to imagine which mediating role the technology they are designing might play in the behaviour of its users. This way they could feed back these anticipations into the design process. Another proposal aims at involving all relevant stakeholders in the design of technology by an augmented version of the Constructive Technology Assessment mehod so that this method becomes an instrument for a democratically organized moralization of technology.

Both approaches try to create a link between the context of design and that of use; and they can be profitably used also for ontology development. Our proposal is different since it is focused on the possibility to make meta data currently used for semiotic annotation of ontologies richer, with the adding of knowledge that is helpful not just to explain how the ontology is made and what is its purpose, but also *why it has been like that*.

In the case of services, this means make explicit the way the services is decomposed in activities and sub-activities and how these sub-activities are organized. This way the user (that might be who uses the ontology or the final user of the application) can evaluate the impact of the service on his/her life and the society. This permits a critical attitude towards some recent developments in the field of design theory such as Interaction Criticism [Bardzell, 2008], and the application of the Daniel Dennett's Design Stance in the user-system interaction [Crilly, 2011].

Naturally, ontology is not the one and only factor that influences the process of mediation of a technology, but it's undoubtedly the most complex to understand and control. Too often developers are not aware of the mediation effect caused by the ontologies they design; this effect may appear, consequently, unintended. Confronting the current proliferation of ontologies in different application domains it's important that these aspects are made explicit, so the developer/designer can make his/hers choice in the most responsible way, i.e. knowing not just the utility of the ontology but also its ethical potential.

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